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Seasonal, interannual, and vertical structure of stratospheric ozone at Mauna Loa Observatory, Hawaii (19.5°N, 155.6°W).

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Abstract

Using more than 800 profiles obtained by the DIAL-ozone lidar of the Jet Propulsion Laboratory (JPL) at the Mauna Loa Observatory (MLO), Hawaii, a wide range of temporal variability of stratospheric ozone is investigated. High-resolution vertical profiles of ozone number density between 15-50 km are routinely obtained several nights a week since July 1993 as part of the Network for the Detection of Stratospheric Change (NDSC). The observed seasonal, interannual, and vertical structure of stratospheric ozone, typical of a low solar activity period (1993-1999), is presented. As expected for tropical latitudes the ozone concentration tends to be higher during the summer months and lower during the winter months throughout the entire stratospheric ozone layer. Still a weak signature of the extra-tropical latitudes consisting in a secondary maximum in late winter can be observed near 19-20 km. Since MLO is located in either side of the so-called subtropical transport barrier, this signature is believed to be related to the intrusion ozone-rich air masses from the midlatitude lower stratosphere which is especially frequent in spring following the final breakdown of the winter polar vortex. Some large day-to-day variability has also been observed in the lowermost stratospheric levels. Its connection with the variability of the tropical tropopause pressure or height will be examined. Finally, the ozone interannual variability including the signatures of the Quasi-Biennial Oscillation (QBO), and the El Nino and the Southern Oscillation (ENSO) will be investigated.

DIAL ozone lidar:

- 2 laser radiations emitted into the atmosphere
- 308 nm weakly absorbed by ozone and 353 nm non-absorbed by ozone
- Light is Rayleigh backscattered by the air molecules
- The two returned signal slopes are compared to deduce ozone number density
- Also use of vibrational Raman scattering (returned wavelengths 331 nm and 385 nm) to minimize the polluting effects of the stratospheric aerosols.
- Main signal corrections: background noise, saturation effects, Rayleigh extinction.

Dataset : (figure 1)

- 800 early night ozone profiles (16-50 km) between Jul-1993 and Jul-1999
- 300 m vertical resolution
- Use of vibrational Raman profiles for lowermost stratosphere
- Instrumental error at ozone peak levels: 1-3%
- Instrumental error at bottom of profiles: 10-15%
- Instrumental error at top of profiles: >20% for altitudes >45 km

Figure 2: Two typical ozone number density profiles at MLO with their associated error bars (1σ)
- Stratospheric ozone peak near 24-25 km all year round
- Almost no seasonal variation in the ozone peak altitude and strength (4-5 1012 cm-3 at 24-26 km)

Figure 3: Seasonal variation (%) of the ozone number density at MLO at 4 different altitudes.
- Weak annual cycle at 18 km and 30 km
- Same phase throughout the all stratosphere: ozone more abundant in summer

Plate 1: Ozone deviation (%) from annual mean at MLO as a function of time of year and altitude
- Ozone maximum in summer in the entire stratosphere
- Seasonal cycle not very pronounced and most observable near 30 km
- High variability in the lowermost stratosphere polluting the annual cycle signature

==> Ozone profile at MLO typical of tropical latitudes

Plate 2: Ozone standard deviation (%) from 33-day running mean at MLO as a function of time of year and altitude
- As for mid- and subtropical latitude ozone variability maximum in the winter/spring lower stratosphere
- Also maximum variability near 30 km in December-January as a result of the residual influence of the midlatitudes stratosphere (winter in Hawaii is influence by northern midlatitude dynamics)
- No conclusion above 45 km due to increasing instrumental noise

==> Ozone at MLO strongly influenced by the tropical tropopause variability and weakly influenced by the winter midlatitude dynamics

Figure 4: Seasonal variation (DU) of ozone column between 20 km and 55 km at MLO.
- Maximum in summer lasting at least 5 months, short-lived minimum in winter

==> Seasonal cycle of the 20-55 km ozone column at both sites mimics that of the ozone number density above the ozone peak

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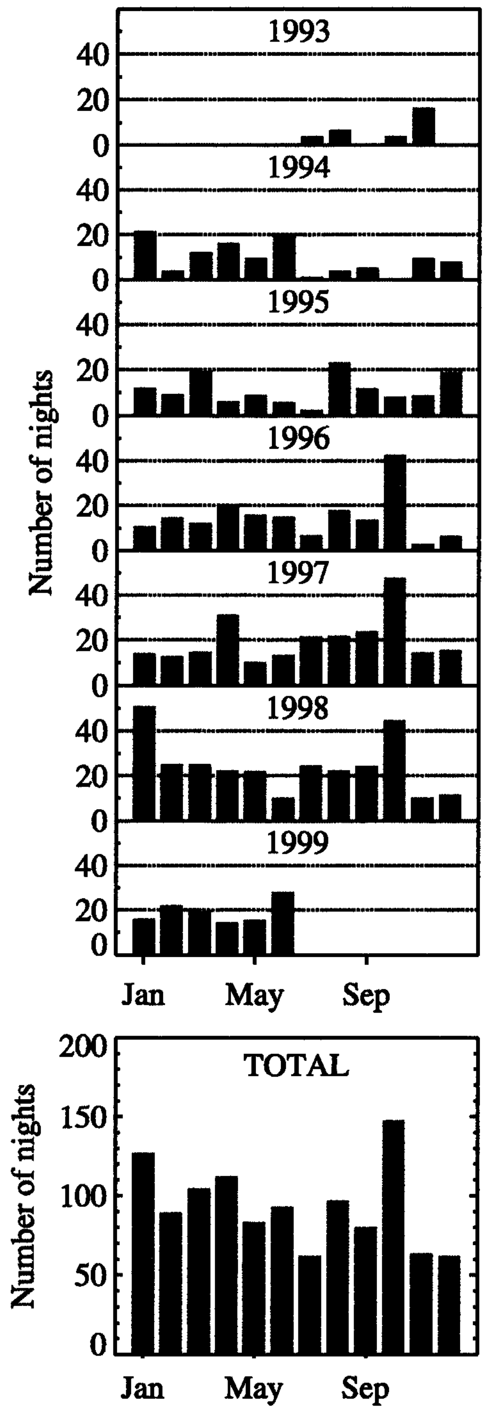
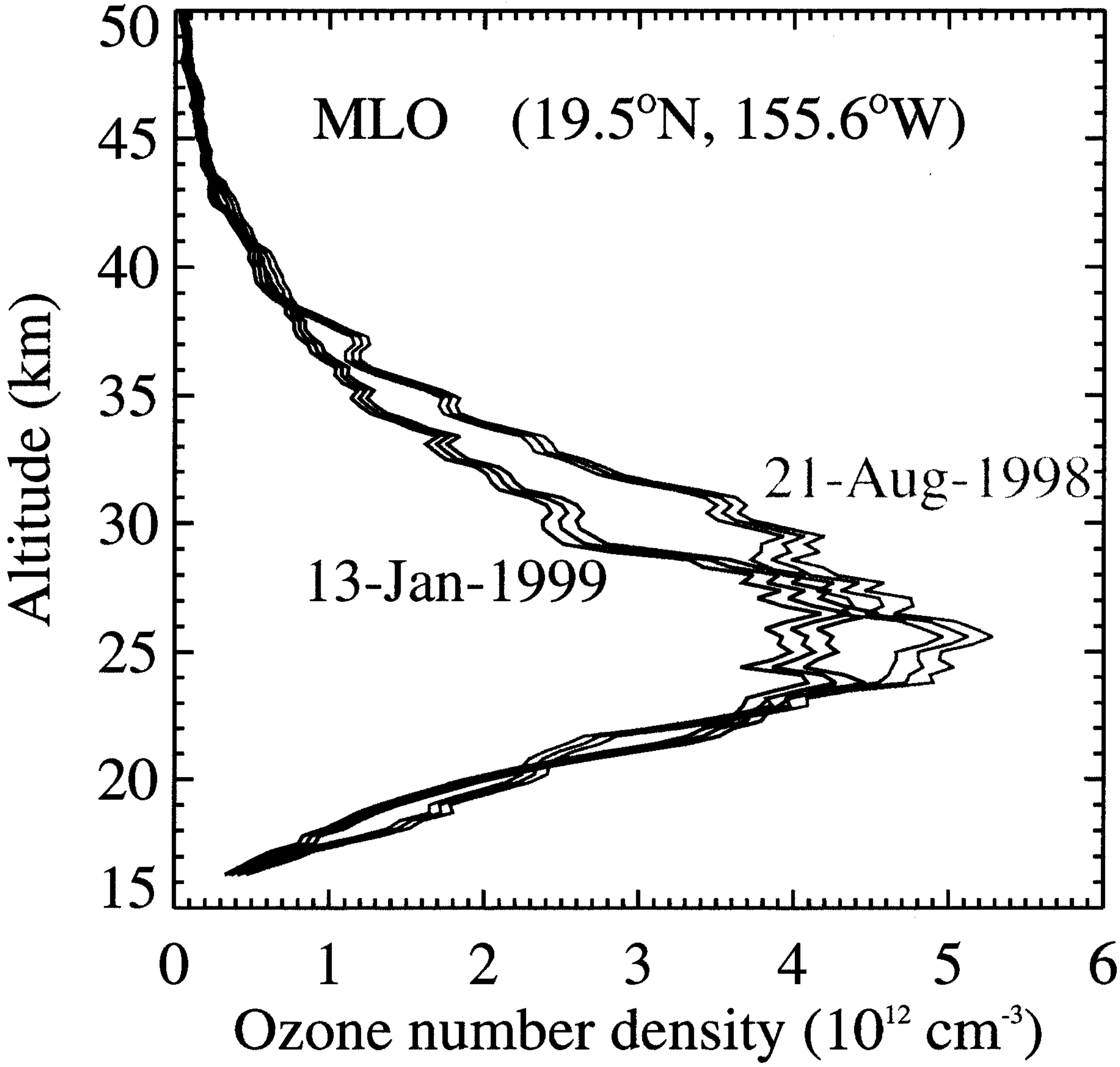
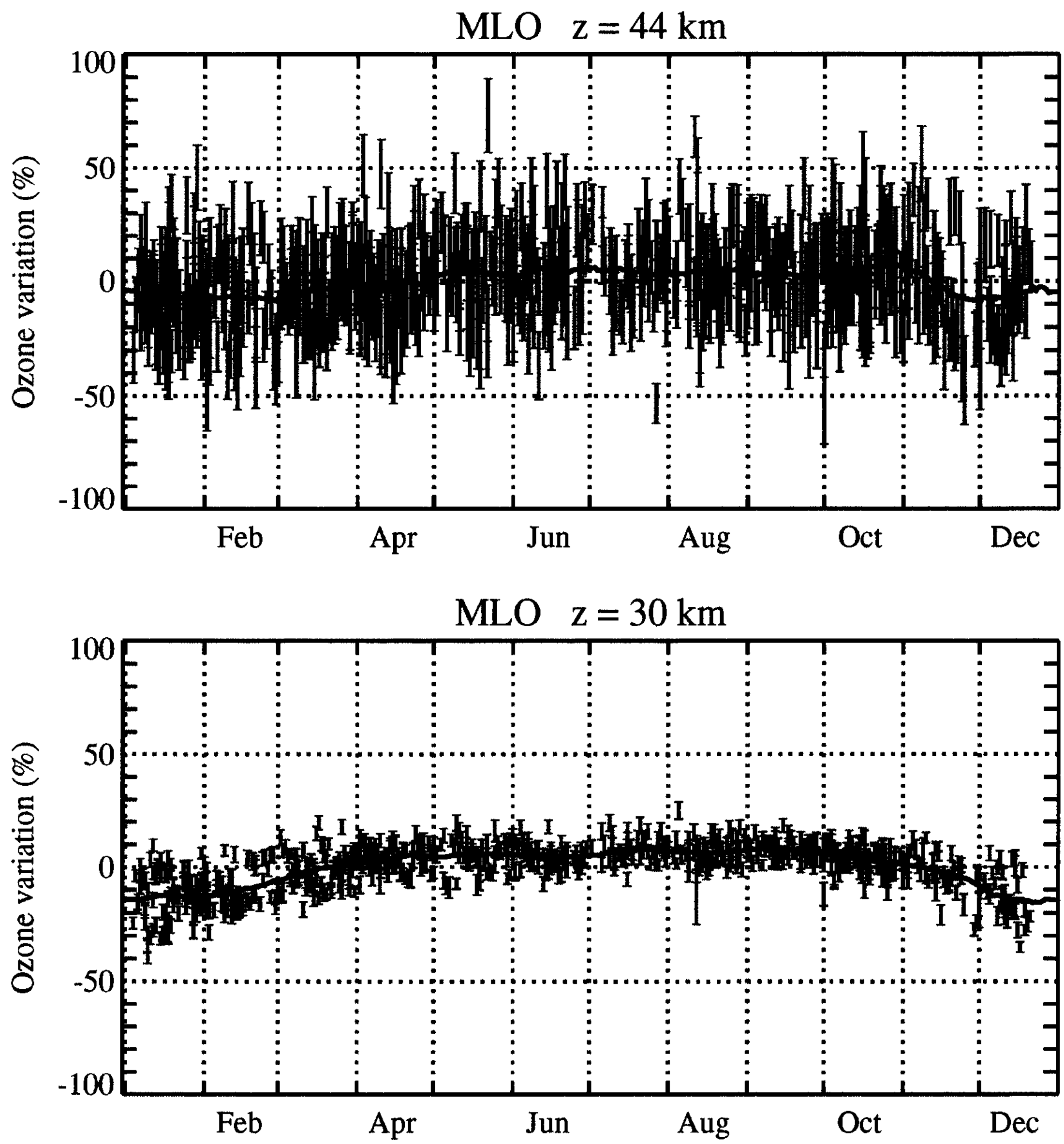

1993
1994
1995
1996
1997
1998
1999
40
20
0
Number of nights
Jan
May
Sep
TOTAL
200
150
100
50
0

Figure 1



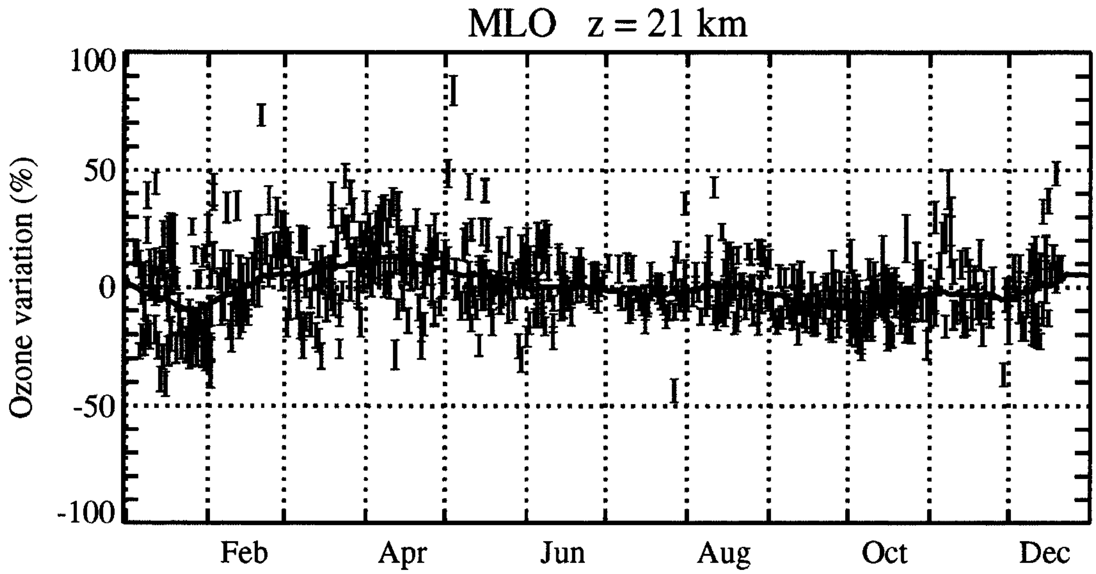
MLO (19.5°N, 155.6°W)
21-Aug-1998
13-Jan-1999
Altitude (km)
Ozone number density (10^12 cm^-3)
50
45
40
35
30
25
20
15
0
1
2
3
4
5
6

Figure 2



MLO z = 44 km
100
50
0
-50
-100
Ozone variation (%)
Feb
Apr
Jun
Aug
Oct
Dec
MLO z = 30 km
100
50
0
-50
-100
Ozone variation (%)
Feb
Apr
Jun
Aug
Oct
Dec

Figure 3



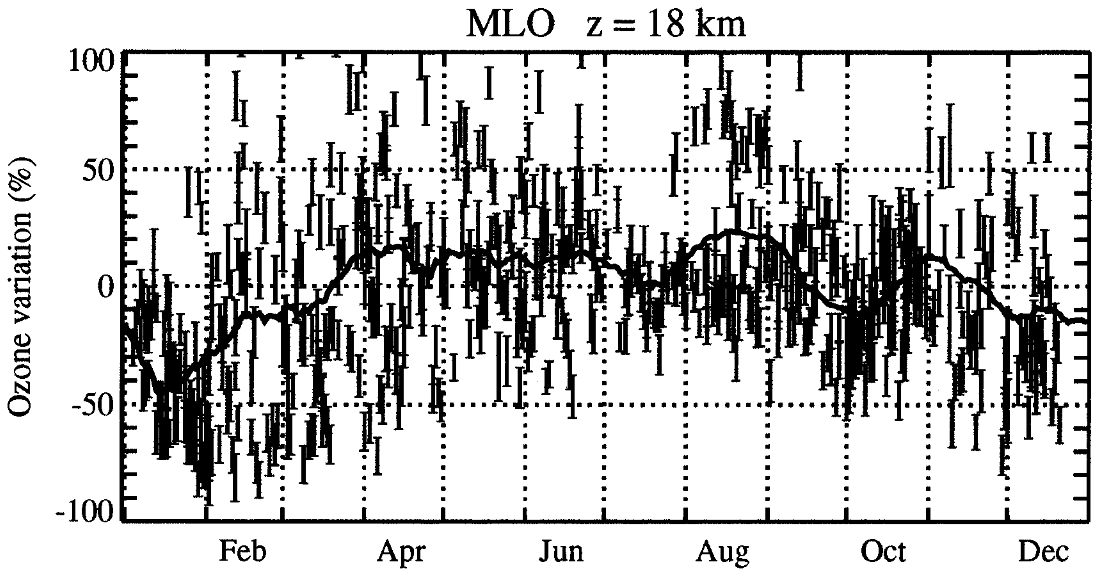
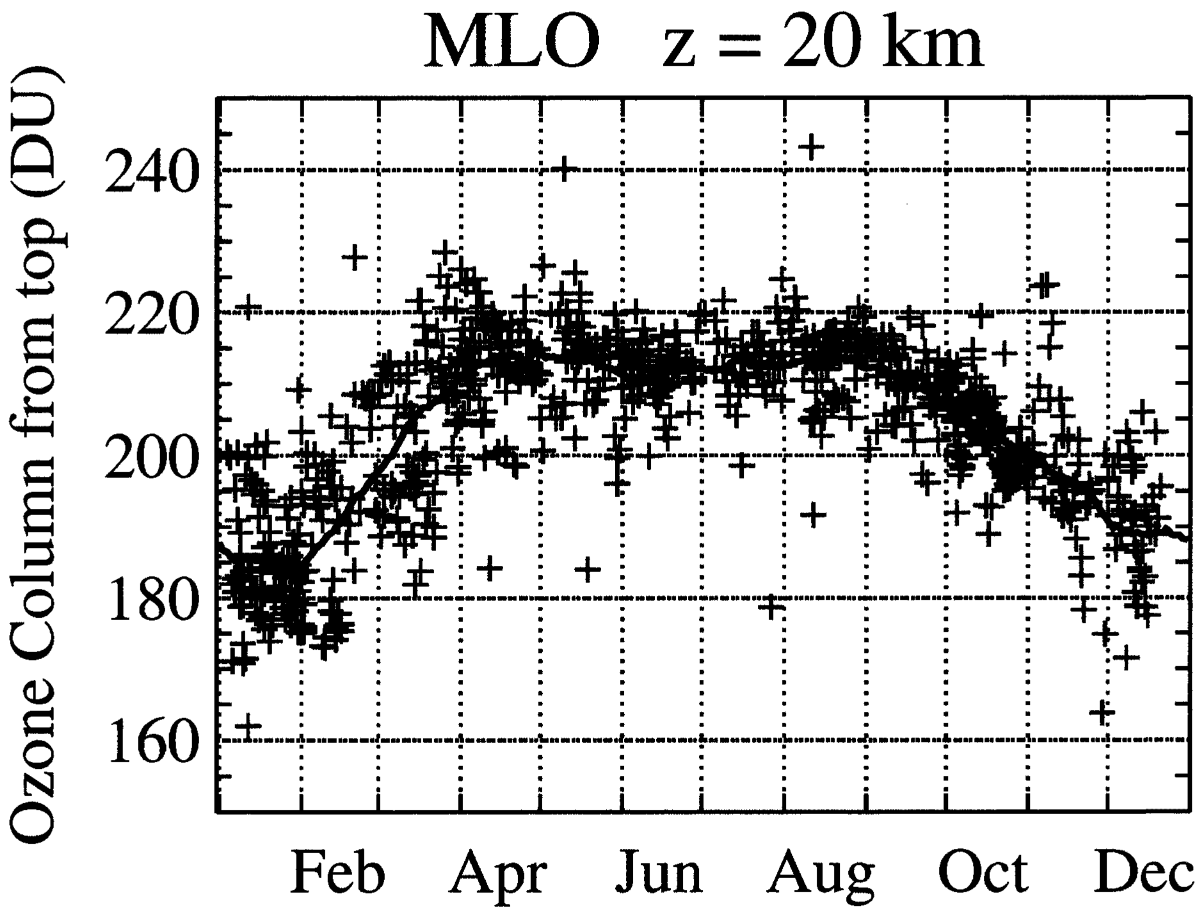


Figure 3 (con't)



MLO z = 20 km
Ozone Column from top (DU)
240
220
200
180
160
Feb
Apr
Jun
Aug
Oct
Dec

Fig 4

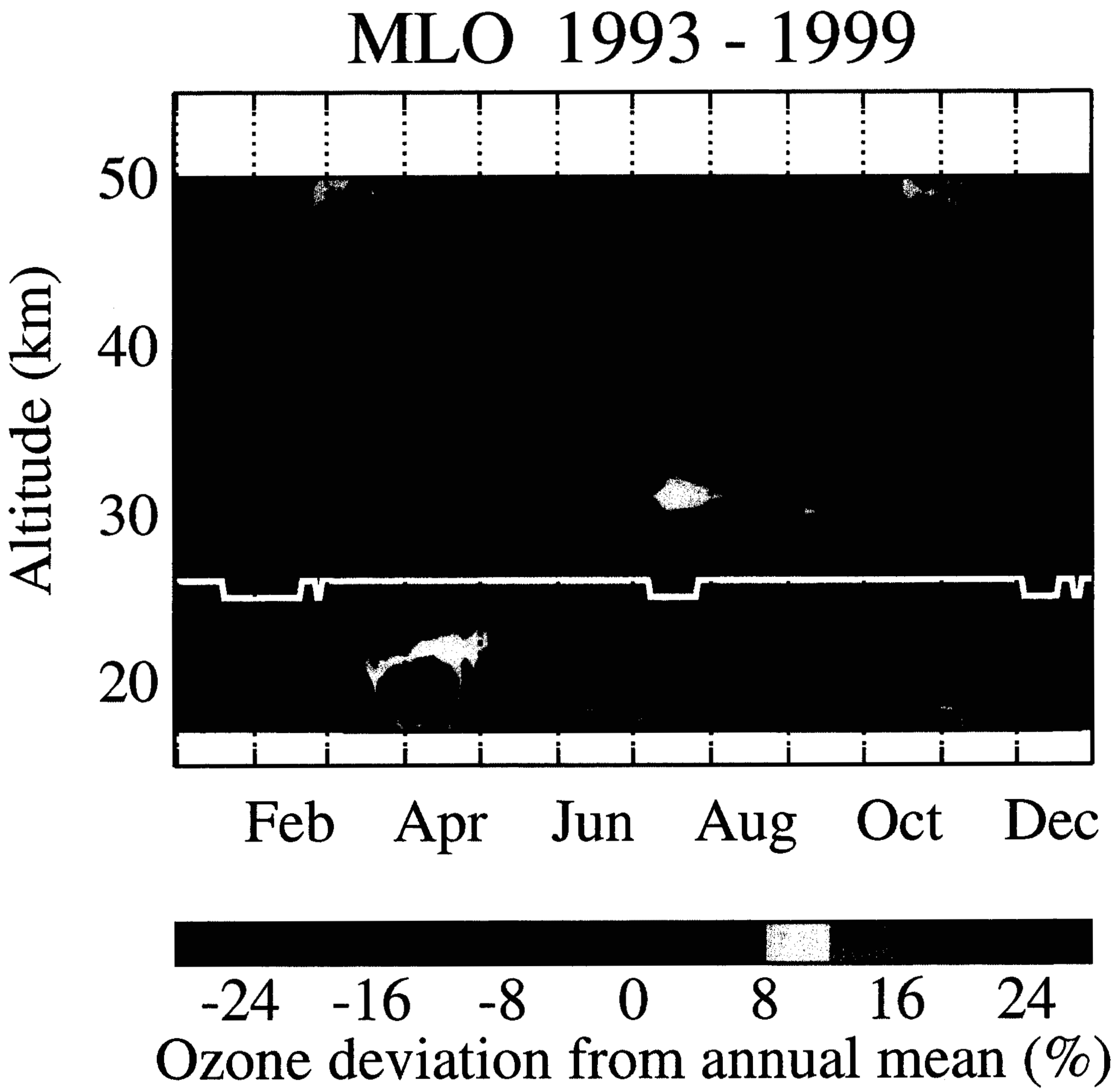

MLO 1993 - 1999
50
40
30
20
Altitude (km)
Feb
Apr
Jun
Aug
Oct
Dec
-24
-16
-8
0
8
16
24
Ozone deviation from annual mean (%)

Plate 1

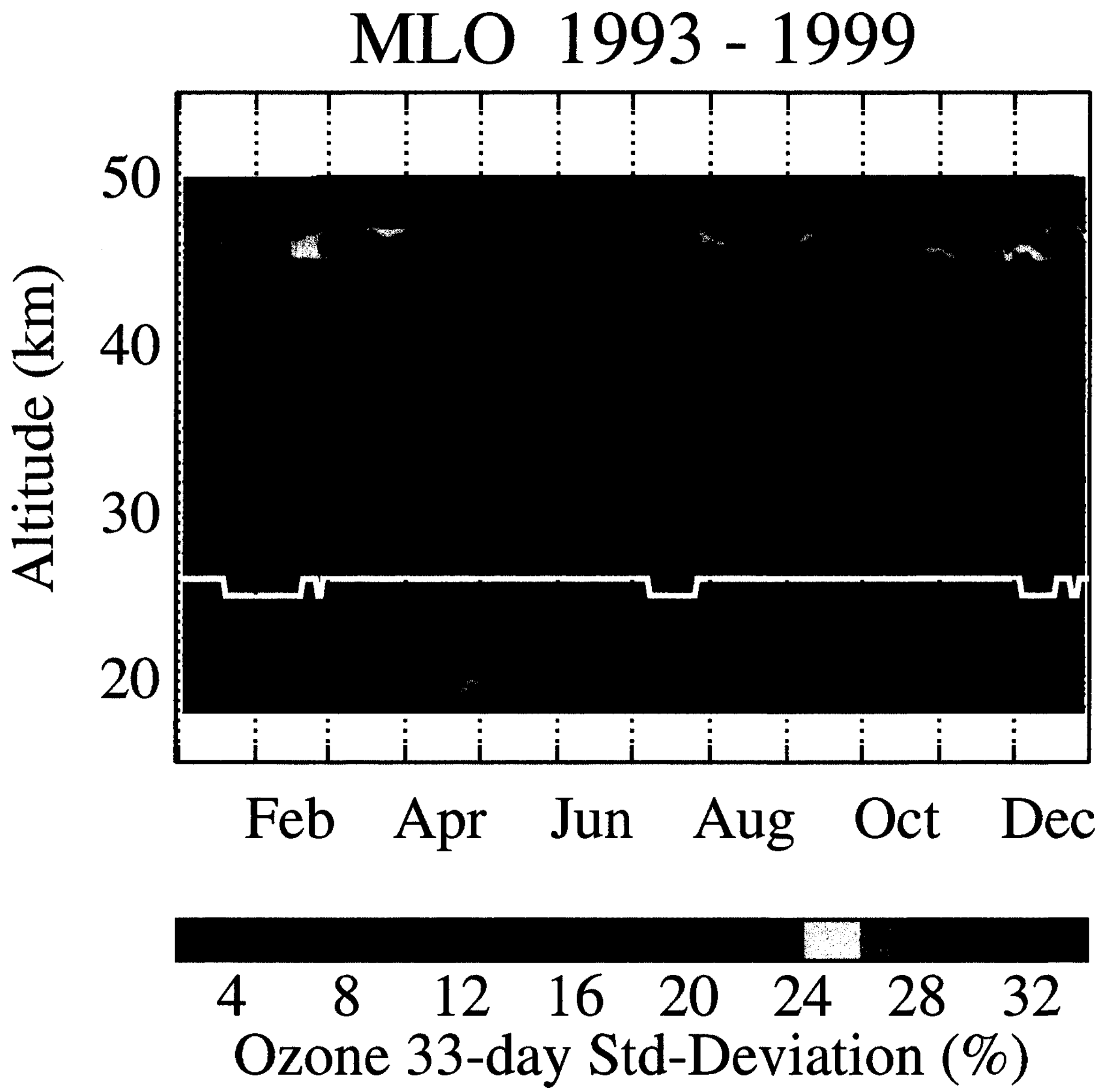

MLO 1993 - 1999
Altitude (km)
50
40
30
20
Feb
Apr
Jun
Aug
Oct
Dec
4
8
12
16
20
24
28
32
Ozone 33-day Std-Deviation (%)

Plate 2